DEVELOPING MALAYSIAN OCEAN WAVE DATABASE USING SATELLITE

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ABSTRACT. Correct wave data is a very important input to predict the performances of the marine vehicles and structures at preliminary design stages particularly regarding safety, effectiveness and comfort of passengers and crews. Presently, available wave data in Malaysian seas are based on visual observations from ships, oil platforms and limited wave buoys whose accuracy, reliability and comprehensiveness are often questioned. This paper presents an effort to develop a more reliable and comprehensive wave database for Malaysia sea areas using satellite altimetry. Significant wave height data is extracted from oceanographic satellite TOPEX/Poseidon for one selected area with the grid of 2°x 2° in the South China. Results are presented in the form of probability distribution functions and compared to data from Global Wave Statistics and Malaysian Meteorological Service.

1. INTRODUCTION

Wave data is important during the design of floating or fixed ocean structures. One important stage in the design of floating structures such as ships involves the calculations of motion characteristics in waves. This will enable designers to predict the performance of the vessel in waves and hence its operability. In the design of offshore structures, an assessment of wave loadings is made to determine the ability of the structure to sustain heavy weather and hence its reliability. A very important input for both design calculations is good and reliable wave data in the form of probability of occurrence of wave heights and periods.

Therefore, there is a need for wave data. For Malaysian waters, designers use data taken from publications by Marine Meteorology and Oceanography, Malaysian Meteorological Service (MMS), for example Monthly Summary of Marine Meteorological Observation 1999 (MMS, 1999) and sometimes Global Wave Statistics (GWS) data published by British Maritime Technology (BMT,1986). These wave data are mainly obtained from voluntary observations from ships, oil platforms and limited wave buoys deployed in the world oceans. The accuracy, reliability and comprehensiveness of such data have often been questioned, for example in Shinkai & Wan, 1996 and Bitner & Cramer, 1994. The data from ships are mostly in main traffic lines, so their sample is very sparse to the whole oceans, and their accuracy is very low. Although wave buoy can provide wave parameters with high accuracy, it is very limited relative to the spacious areas of the whole oceans and there is no buoy available in some areas.

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Remote sensing is a new approach to get the information on waves over vast sea areas. Altimetry and Synthetic Aperture Radar (SAR) have been used to observe the significant wave height and directional spectrum, respectively. Many satellites have been launched with altimetry or SAR until now, such as TOPEX/Poseidon, ERS-1/2 and Jason 1. Details about satellite altimetry can be found in (Fu & Cazenave,2001).

Omar et al.,2004 presented an effort to develop a more reliable and comprehensive wave database for Malaysian sea areas by using altimetry data from TOPEX/Poseidon (T/P) satellite, extracting probability of occurrence of wave heights. The data were analysed and presented in the form of monthly averages of significant wave height probability of occurrences. In the present paper, the method is extended to derivation of joint probability distribution of wave heights and periods. Data is presented in a manner similar to that of GWS. Results of application of the method are described for a sea area close to Sarawak Coast. The area selected is in the South China Sea between the longitude of 112°E to 114°E and latitude 4°N to 6°N from 1999 to 2001. This area was chosen because of the availability of data in MMS for easier comparison.

2 COMPARISONS WITH MMS DATA

Comparison between quarterly T/P data and MMS data is given in Table 1 for each individual year as well as for the 3-year average. The 3-year averages are also plotted in Figure 1. It needs to be noted that the comparisons shown are between averages from altimetry measurements and visual observations, which are in themselves not very accurate. Nevertheless, the results indicate that significant wave heights from T/P generally agree well with those from MMS. There is a larger variation in the fourth quarter average. The difference could be attributed to the fact that there are fewer reports from ships during the monsoon seasons. For example in 2002, there are nearly one hundred ship reports in the month of July compared to only about 30 in the month of December (MMS, 2002). Moreover, the reports that come in are from masters of ships, which are in the open sea, most of whom will try to avoid heavy seas. Thus the observations from ships can be expected to be lower compared to the readings from T/P.

Table 1. Comparison of average of significant wave height between MMS and Topex/Poseidon quarterly for 1999-2001

	1999		2000		2001		3-Year Average	
	MMS	T/P	MMS	T/P	MMS	T/P	MMS	T/P
Q01	1.1	1.1	1	1	0.9	0.8	1.000	0.967
Q02	0.6	0.6	0.7	0.7	0.7	0.8	0.667	0.700
Q03	0.8	0.6	0.8	0.7	0.8	0.7	0.800	0.667
Q04	1.2	1	0.9	1.4	0.8	1.2	0.967	1.200

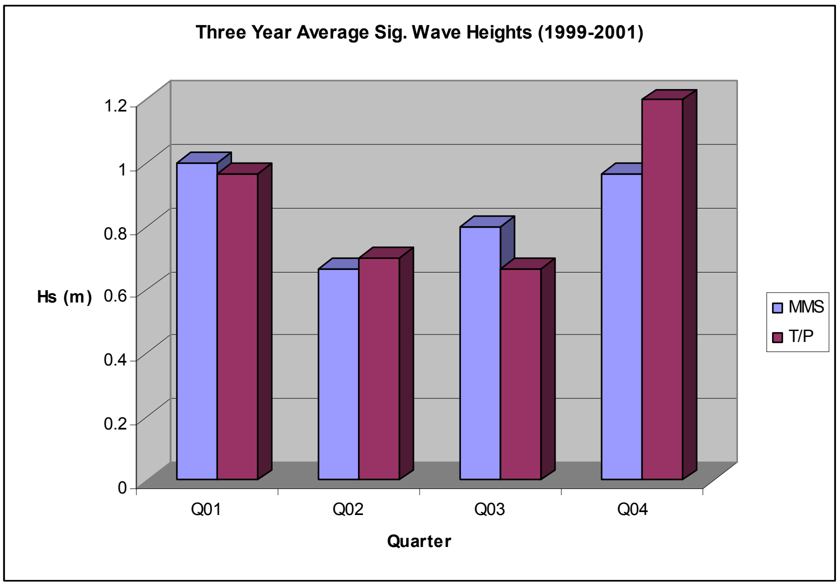

Figure 1 . Comparison of 3-year quarterly average of significant wave height between MMS and Topex/Poseidon

3. DETERMINATION OF WAVE HEIGHTS-PERIODS JOINT PROBABILITY DISTRIBUTION FUNCTION

The probability of occurrence of significant wave heights is normally enough for most engineering design calculations. However, in some cases such as the use of sea spectra to estimate downtime of floating vessels, data regarding wave periods is required.

In the present paper the data is further analysed using a method which make use of altimeter measurements of the significant wave heights, wind speeds, and derive a function relating wave heights, wind speeds and wave periods based on assumptions of a "saturated" sea conditions and "negligible swell" based on Hwang et al.(1997). Recent study of tilting effects on radar backscatter indicates that the altimeter wind speed (U) measurements are accurate to better than 1 m/s, and are within the accuracy of buoy measurements. The combination of wind speed and wave height further yields the information of wave period (T). Empirically, peak period of the wave field, T, is related to wind speed, U, and wave height, H, and is given by

$$U/(gT) = 0.048(U^2/(gH))^{0.67} \qquad (1)$$

Where g is the gravitational constant. The results are presented in a format similar to the GWS scatter diagram as shown in Table 2.

4. COMPARISON WITH GWS DATA

Comparisons of marginal probabilities of occurrence of wave heights and of occurrence of wave periods were made with GWS data for Area 62. Figure 2 shows a comparison of probability occurrence of wave heights obtained from T/P and the original GWS data. The results indicate that the data provided by T/P at the 2° x 2° grid is markedly different from that given by GWS Area 62. It should be noted that GWS gives wave height probability distribution for a large area covering Gulf of Siam and most of China Sea. As such, wave heights above 5 metres are considered probable whilst in the selected location for T/P, such wave heights are never expected to occur. Thus designing ocean structures in the selected area using GWS data could lead to erroneous results, at best over design.

Table 2: T/P Joint annual probability distribution for 1999-2001

SIGNIFICANT WAVE HEIGHT (m) \ ZERO CROSSING PERIOD (s)	<3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	TOTAL
TOTAL	46	160	233	162	207	85	46	37	9	7	7	1000
>14	-	-	-	-	-	-	-	-	-	-	-	-
13-14	-	-	-	-	-	-	-	-	-	-	-	-
12-13	-	-	-	-	-	-	-	-	-	-	-	-
11-12	-	-	-	-	-	-	-	-	-	-	-	-
10-11	-	-	-	-	-	-	-	-	-	-	-	-
9-10	-	-	-	-	-	-	-	-	-	-	-	-
8-9	-	-	-	-	-	-	-	-	-	-	-	-
7-8	-	-	-	-	-	-	-	-	-	-	-	-
6-7	-	-	-	-	-	-	-	-	-	-	-	-
5-6	-	-	-	-	-	-	-	-	-	-	-	-
4-5	-	-	-	-	-	-	-	-	-	-	-	2
3-4	-	-	-	-	-	-	3	7	-	-	-	9
2-3	-	-	-	-	8	20	4	-	-	-	-	32
1-2	-	-	5	74	151	38	18	14	5	7	7	319
0-1	46	160	228	88	48	27	21	16	4	-	-	637

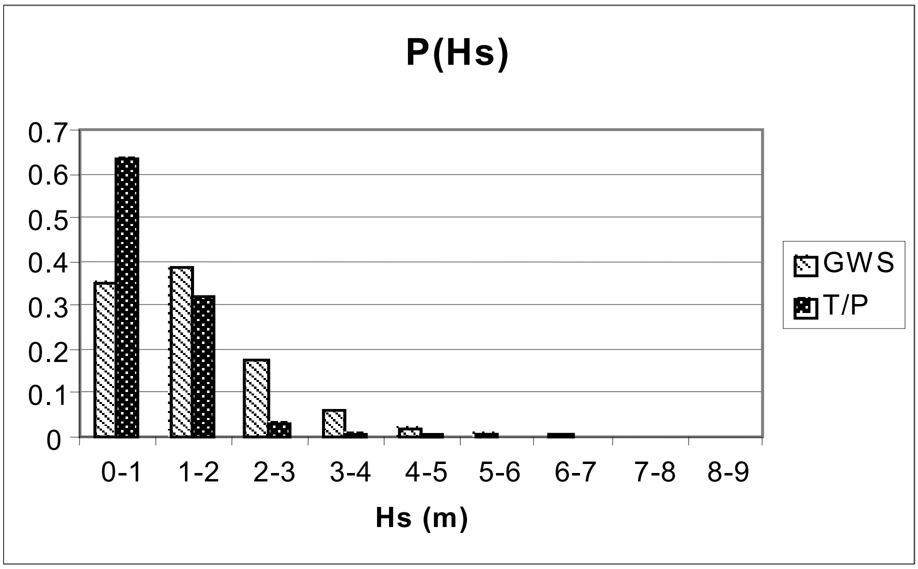

Figure 2: Comparison of probability of occurrence of wave heights

Comparison of probability of occurrence of wave periods is shown in Figure 3. Using the data from GWS and T/P it is shown that there is a significantly difference between these data. There is a great need to carry out the validation purposes of this method.

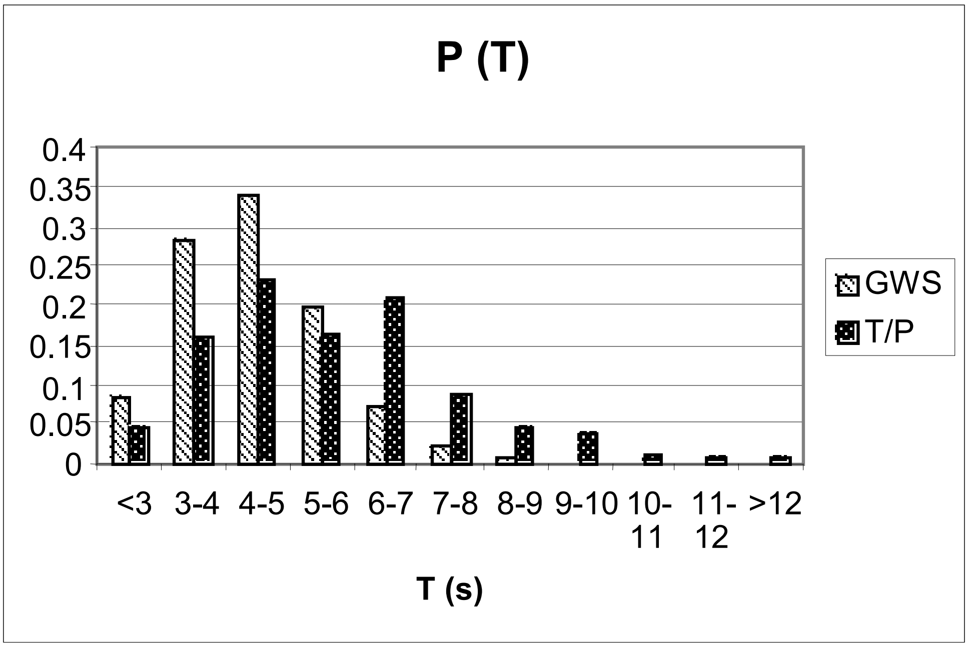

Figure 3: Comparison of probability of occurrence of wave periods

5.CONCLUSIONS

It has been shown that more comprehensive data can be obtained for all sea areas using satellite altimetry data. Comparison with presently available data based on visual observation has shown encouraging results. The data provided by TOPEX/Poseidon satellite can be used to derive wave periods, which can then be used to obtain joint probability distribution of wave heights and periods. However there is a need to obtain in-situ measurement for validation of these results.

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REFERENCES

Bitner-Gregersen E.M. and Cramer E. H., (1994). *Accuracy of the Global Wave Statistics Data*, IOPEC, Japan.

British Maritime Technology Ltd., (BMT) (1986). *Global Wave Statistic*. Unwin, London.

Fu, L-L. and Cazenave, A. (ed.) (2001). *Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Application*, Academic Press, UK.

Hwang, P.A., Teague, W.J., Wang D.W.C., Thompson, E.F., Jacobs, G.A. (1997) *A Wave/Wind Climatology For The Gulf Of Mexico,* Proceeding of 7th International Offshore and Polar Engineering Conference, USA.

Malaysian Meteorological Services Department (MMS), *Monthly Summary of Marine Meteorological* Observation, 1999, 2000, 2001

Malaysian Meteorological Services Department (MMS), Raw Metrological data for Malaysian Waters 2002, Malaysian Meteorological Department, *(unpublished).*

Omar Yaakob, Norazimar Zainudin, Ramli Shariff (2004), *Developing Malaysian Wave Database using Satellite Altimetry,* Proceedings of 4th Regional Conference on Marine Technology, MARTEC 2004, Universiti Teknologi Malaysia, Johor Bahru.

Shinkai A. and Wan S., (1996). *Statistical Characteristics of the Global Wave Statistics Data and Long-term Predictions*, ASME, Japan.